Powerhouse Dynamics
WiTemp+
FCC Compliance Operational Description

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Overview

This document describes the operation of Powerhouse Dynamics' WiTemp+ sensor and how it complies with the applicable FCC rules regarding its runtime performance.

Hardware

The WiTemp+ is a battery powered temperature and dry contact sensor that periodically transmits sensor readings to a central collector device called a Gateway within the 915MHz ISM band. It has one internal 1-Wire temperature sensor, and optionally supports one external 1-Wire temperature sensor and one dry contact input. In addition, the battery voltage is also monitored and reported to the Gateway. The radio, a transmitter only, is integrated with a small microprocessor. The supplied battery voltage is conditioned by a power supply that supplies a constant voltage of 3.3V to the digital logic and RF transmitter. Two 1.5V AA lithium or alkaline cells in series provide a nominal 3V source to the onboard power supply. A single red LED is the only integrated hardware user interface and is used to show RF transmission activity.

Firmware

The WiTemp+ firmware runs on the microprocessor that is integrated with the RF transmitter. More than 99% of the time the microprocessor is in a deep sleep state and the RF transmitter is off. Periodically, it will wake from sleep mode, take temperature, dry contact, and battery voltage readings and then transmit those readings to the Gateway. Additionally, the WiTemp+ will report, as necessary, its firmware version or other diagnostic values as part of the transmitted readings.

There are two periodic modes. Install mode occurs when the device is initially powered (batteries inserted.) It will transmit readings no faster than once every 10 seconds and no slower than once every 12 seconds from the end of the last transmission for about the first eight minutes of operation. After Install mode expires the device will enter Normal mode until the next time the batteries are removed and replaced. During Normal mode it will transmit readings at a random interval no faster than once every 57 seconds and no slower than once every 63 seconds, and generally averaging about one reading every 60 seconds.

RF Transmitter

The radio is a transmitter only in the 915MHz ISM band. The modulation is OOK (On-Off Keying) where a logical bit value of 1 is represented by a signal being transmitted and a logical bit value of 0 is represented by the absence of a signal being transmitted. The bit rate of the transmissions is 10000bps. Since the radio is a transmitter only it is not possible to detect if the transmission channel is in use, therefore the firmware randomizes transmission times to prevent permanent cyclic RF collisions due to multiple synchronized transmitters.

The RF transmitter outputs a signal at 10dBm power utilizing a proprietary stamped metal. The transmissions mechanism uses spread spectrum frequency hopping to distribute the utilized bandwidth across a wider swath of the 915MHz band. The frequency hopping uses 51 channels starting at 902.5MHz and ending at 905.3MHz equally spaced with 56kHz between channels. Three of the 51 channels are used to synchronize the channel hopping sequence with the gateway. These three synchronization channels are at 903.34MHz, 904.068MHz, and 904.796MHz. The other 48 data channels are used to transmit the sensor readings.

Each transmission on a specific channel starts with a 4 byte preamble of alternating 1's and 0's. The preamble is followed by a 4 byte sync word, that allows the Gateway to synchronize its receiver with the data stream. The sync word is followed by a 1 byte length byte that indicates the number of data bytes that will be transmitted as part of the message. Following the length byte exactly length bytes of data are transmitted.

The three synchronization channels only transmit 2 bytes of data that encodes the channel on which the WiTemp+ will transmit its actual sensor data. Each of the forty-eight data channels can transmit an absolute maximum payload of 176 bytes of encoded sensor data, but typically less than that depending on installation of an external 1-Wire temperature sensor and if diagnostic data is also transmitted.

After the WiTemp+ takes its sensor readings it will transmit a channel synchronization message on each of the three synchronization channels. For each sensor reading cycle the transmission sequence of the three synchronization channels is randomized. The reason for transmitting synchronization data on three different channels is to provide frequency diversity for the Gateway receiver to listen to a different synchronization channel in the case a specific synchronization channel is unreliable in a particular customer environment.

After sending the third synchronization message, the WiTemp+ will wait approximately 50ms before it transmits the sensor readings on the data channel just specified in each of the synchronization messages. This permits the Gateway time to process the synchronization message and change receive channels in preparation to receive the sensor data message. For each sensor reading cycle the data channel is pseudo-randomly sequenced through all 48 data channels such that all data channels are used equally and not simply used in a predictable pattern, such as ascending or descending RF frequencies.

There are no retransmissions or other acknowledgement or support transmissions except those previously described.

Bandwidth Calculations

Based on the description of the RF transmitter in the previous sections the absolute maximum transmission time on any given channel for each sensor reading data transmission is:

Maximum Packet Framing Bytes: 9

Maximum Packet Sensor Data Bytes: 176

(9 + 176)bytes * 8bits/bytes * (1/10000bps) = 148ms

And the maximum transmission time for each synchronization channel transmission is:

Maximum Packet Framing Bytes: 9

Maximum Packet Synchronization Bytes: 2

(9 + 2)bytes * 8bits/bytes * (1/10000bps) = 8.8ms

Over the course if a 20s sliding transmission window the same data channel will not be reused, therefore the maximum utilization for any data channel is 148ms. However, over the course of a 20s sliding transmission window each synchronization channel will be used twice for a maximum utilization of 17.6ms.

Section 15.231 Compliance

The WiTemp+ complies with section 15.231 under paragraph (e) as an intentional radiator operating at a periodic rate. The WiTemp+ never transmits for more than 1 second. The silent period is no less than 10s between transmissions. The calculation for the transmission period for each sensor reading combining the three synchronization transmissions and the data transmission is:

8.8ms * 3 synchronization + 50ms delay + 148ms data = 224.4ms

Therefore, the minimum silent period of 10s during Install mode is 10s/224.4ms = 44.5 times the transmission period. And the minimum silent period of 57s during Normal mode is 57s/224.4ms = 254 times the transmission period.

Sections 15.214, 15.233 Compliance

The WiTemp+ is not a cordless telephone, therefore these sections are not applicable.

Section 15.121 Compliance

The WiTemp+ is not modifiable to become a scanning receiver within the restricted cellular bands therefore it is compliant with this section.

Description of Circuitry and Devices

L1,L2,L6 inductors and C3,C5,C12 capacitors on the RF output of the transmitter provide the filtering and matching for the transmitted signal. These components are tuned for the 915MHz ISM band. A precision cut wire antenna is soldered at the end of this filtering and matching circuit.

U2 is the combined RF transmitter and microprocessor. The microprocessor's firmware controls the operation of the RF transmitter. Resistor R2 ensures the radio is powered to a known off state. Capacitors C6,C7,C14, C15 provide power supply decoupling for both the microprocessor and RF transmitter. X1 is a 26MHz crystal that provides a stable source frequency for generating the 915MHz band transmissions.

U3 is the DC to DC power supply, which converts the battery voltage into a stable 3.3V for use by the digital logic and RF transmitter. The input side of U3 includes; R3 a 0ohm jumper, R5 a current limiting resistor for battery voltage sensing by the microprocessor, C10 a filtering capacitor, and L8 a feedback inductor. The output side of U3 includes; R6/R7 voltage setting resistors, C11, C8, C9 filtering and bulk capacitors, and R4 a 0ohm jumper.

U4 is a 1-Wire integrated temperature sensor connected the same bus exposed on Pin 1 of external connector TB1, which permits a single external 1-Wire temperature sensor to be connected. Resistor R8 and Diode clamp D1 are present to reduce the potential of hardware damage from high voltage/high current external sources. Resistor R8 is a pull-up resistor for the 1-Wire bus.

Pin 3 of external connector TB1 is the external dry contact input. Resistor R11 and Diode clamp D2 are present to reduce the potential of hardware damage from high voltage/high current external sources. R10 is a current limiting resistor on the signal generated by the microprocessor to detect if the dry contact is open or closed. R12 is a current limiting resistor for the red LED D3.

Section 15.203 Compliance

The WiTemp+ has a factory installed precision length wire antenna permanently soldered to the circuit board. Therefore the WiTemp+ complies with this section.

Location and Intended Use

The WiTemp+ is marketed as a Class A device for use in a commercial, industrial, or business environment as an optional component that is one part of a portfolio of hardware and software solutions for monitoring energy utilization and food safety compliance. A typical use case would be for a restaurant to use the WiTemp+ to monitor the temperature of a food cart, or the temperature of a refrigeration unit.